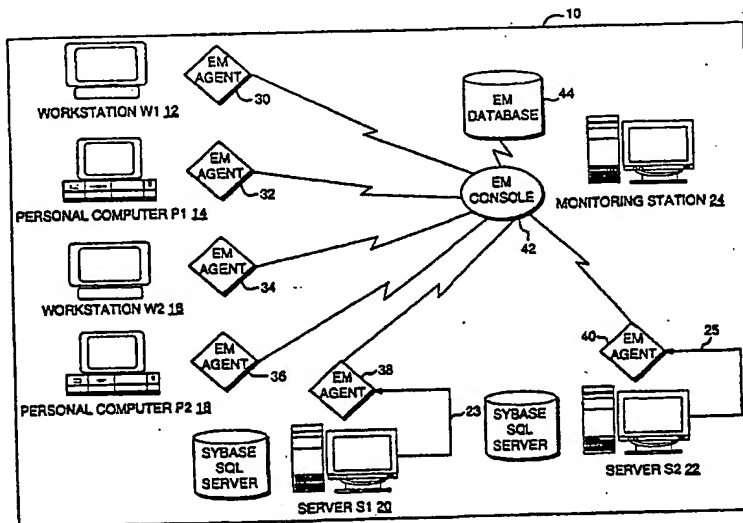


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : H04L 12/26, 29/06		A1	(11) International Publication Number: WO 98/42103
			(43) International Publication Date: 24 September 1998 (24.09.98)
(21) International Application Number: PCT/US98/05162 (22) International Filing Date: 17 March 1998 (17.03.98) (30) Priority Data: 08/821,698 20 March 1997 (20.03.97) US (71) Applicant: FIRSTSENSE SOFTWARE, INC. [US/US]; 21 B Street, Burlington, MA 01803 (US). (72) Inventors: AGARWAL, Neeraj; 26 Gosselin Road, Nashua, NH 03062 (US). PERRET, Pierre; 4326 W. Michigan Avenue, Glendale, AZ 85308 (US). MCMENEMY, Michael, G.; 28 Parker Drive, Merrimack, NH 03054 (US). (74) Agents: MUIRHEAD, Donald, W. et al.; Foley, Hoag & Eliot LLP, One Post Office Square, Boston, MA 02109 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	

(54) Title: SYSTEMS AND METHODS FOR MONITORING DISTRIBUTED APPLICATIONS



## (57) Abstract

Systems and methods for automated monitoring and management of distributed applications, client/server databases, networks and systems across heterogeneous environment. The invention employs distributed, automated intelligent monitoring agents with embedded sensing technology which is knowledgeable of application protocols, to monitor continuously the network environment in real time. To this end, the monitoring agent can be located on each client and server in the network. The monitoring agent can couple to the communications stack for monitoring the data that is being passed between the client and the network, of a server in the network. The data can be collected and employed for trouble shooting trend analysis, resource planning, security auditing, accounting and chargeback, as well as other applications.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

5

## **SYSTEMS AND METHODS FOR MONITORING DISTRIBUTED APPLICATIONS**

### **FIELD OF THE INVENTION**

The invention relates to systems and methods for monitoring and managing distributed computing environments, and more particularly, to systems and methods for monitoring enterprise wide operation of a distributed computing system to develop business transaction level management data for system performance, usage trends, security auditing, capacity planning, and exceptions.

### **BACKGROUND OF THE INVENTION**

A distributed computing architecture provides physical and logical distribution computing functions across many computers connected by a network system. Typically, the client initiates a service request to a server across the network. The server responds to the client's request by performing one or more database, file, printing, or other services. During the operation, the client and the server exchange data and individually perform data processing functions necessary for completing the operation. Complexity can arise because a single server can service multiple clients simultaneously, while a client can concurrently access the services of multiple servers. Moreover, servers can act as clients to other servers. Accordingly, distributed computer systems can have complex multi-tier distributed architectures.

Despite its complexity, distributed computing architectures have been remarkably successful in providing users with sophisticated and powerful systems for efficiently processing large amounts of data and providing rapid digital communication between multiple stations. The power of these systems has lead to the wide-spread proliferation of distributed computing architectures and has further resulted in the development of a plethora of distributed computing services such as client/server databases, distributed applications and networks across heterogeneous environments. Moreover, new technologies continue to fuel the growth of distributed systems. For example, the development of internet and intranet systems suitable for the commercial environment has created a burst of growth in the distributed computing field.

Although distributed computing architectures provide users with efficient and powerful tools, the complexity and sophistication of the architecture makes the

5 implementation, deployment, and operation of the actual systems quite difficult. For  
example, a typical relational client/server database system will include a database server for  
providing a number of database services to a plurality of clients. The distributed architecture  
requires that each client is capable of properly communicating with the server, and that the  
server is capable of coordinating the multiple service requests received from the clients and  
10 maintaining data coherency for a data repository that could be distributed among several  
network memory devices. Loading such a system onto a computer network is a difficult task,  
made complex because electronic communications occurring between clients elements and  
servers occurs asynchronously, intermittently and quite rapidly. Accordingly, complex  
diagnostic and management tools are required to implement these distributed systems and to  
15 analyze and improve performance.

The complexity of a distributed computing architecture makes diagnosing system  
failures a difficult task. The asynchronous and rapid nature of communications between the  
distributed network components complicates the task significantly. Accordingly, a diagnostic  
20 technician has a difficult time in monitoring system operation in order to detect the events  
which cause system failure.

Responsive to this need for diagnostic and development tools, computer engineers  
have developed network monitoring systems which couple into the communication channels  
25 of the network to monitor transactions between clients and servers. These systems are often  
hardware devices that couple into the physical layer of the network system to monitor  
communications. Accordingly, this requires that each physical connection between a client  
and a server include an interconnected hardware device. These devices monitor the data  
transactions that occur. By generating records of these data transactions, a system technician  
30 can attempt to identify the events which lead to the system failure.

Although these systems work, they require that the hardware devices are capable of  
detecting and recording each data transaction that occurs between the client and the server.  
This requires that the hardware device read each packet of data being transferred across the  
35 network to determine if the data being sent is associated with the client or the server being  
monitored. However, the asynchronous and rapid nature of the data transactions that occur  
between clients and servers renders these devices susceptible to error for failure to detect  
every transaction that occurs. The technician may have only a partial record of the  
transactions which occurred between the client and the server, and therefore, an incomplete  
40 record that is unreliable for purposes of determining the cause of the system failure.

5 Other management tools exist that map a centralized system management model onto  
a distributed environment by implementing an agent-console architecture. In this  
architecture, agents continuously poll the servers and log files for the system, the network, or  
the applications to collect usage data and to determine if any "exception" has occurred. The  
console is a central management station through which the command and control functions  
10 are implemented. This architecture has several shortcomings. First, the continuous polling  
function employs valuable resources and degrades server performance. This is particularly  
true for metrics that require fine grain analysis of system activity and require constant polling.  
Second, the agents are at the server component level. Thus, usage, performance and  
exception statistics are only available at the component level and no measure is provided for  
15 end-to-end resource utilization, and no measure of the other participating components is  
made.

An alternative approach proposed by certain framework vendors has included an  
application program interface (API) to a set of resources that management tools can employ  
20 to monitor system performance. This approach requires that existing distributed applications  
operating on the system be edited and re-compiled to include API calls to the various system  
monitoring resources. Accordingly, this is a highly intrusive approach to system monitoring  
that is dependent upon the cooperation of every vendor providing an application program  
running on the distributed system.

25

### SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide improved systems for  
monitoring distributed computer systems.

30

It is a further object of the invention to provide monitoring systems that yield business  
transaction level data.

35

It is a yet a further object of the invention to provide less intrusive monitoring systems  
that are readily scaled.

40

It is still a further object of the invention to provide distributed system management  
tools that characterize resource consumption at a business transaction level and take into  
account system, network, server and other component activities performed in furtherance of a  
business transaction.

5       The invention features systems and methods for automated monitoring and  
management of distributed applications, client/server databases, networks and systems,  
including those that operate across heterogeneous environments. The invention employs  
distributed, automated, intelligent monitoring agents with embedded sensing technology  
10       knowledgeable of application protocols to continuously monitor the network environment in  
real time. The monitoring agents can be located on each client and server in the network.  
The monitoring agent couples to the network communications stack and monitors the data  
that is being passed between the client and the network, and between the server and the  
network. By coupling into the communications stack, the agent can monitor all data being  
15       passed to any process running on the client. Optionally, the agents can be directed to monitor  
communications with a selected group of servers, such that all data being passed from or to  
these servers will be detected and stored by the agent. The agent can store all the collected  
data in a database. As the agents are aware of the application protocols, the systems are  
capable of collecting useful data for trouble-shooting, trend analysis, resource planning,  
security auditing, accounting and chargeback, and other applications.

20       In one embodiment, the invention features a system for monitoring a server program  
operating in a network. The system can include a client (e.g. a computer workstation or a  
server) that has a communication stack for passing data between the network and the client.  
The system further includes a monitor that has an interface for coupling into the  
25       communications stack and for monitoring the data being passed between the client and the  
network, and a filter module for processing the data to detect portions of that data which is  
representative of communications associated with that server program. The system can  
further include a data memory for storing the detected portions of data.

30       The system can also include an agent for coupling into the data memory and for  
processing the detected portions of data to generate information representative of an operation  
of the server program. A user module can operate to receive information from the agent and  
process the information to determine the characteristic of the server program operation. The  
characteristic can be representative of a volume of use for the server program and response  
35       time or other characteristics.

      The system also can include error detectors that monitor the information being passed  
between a server and a client to detect the occurrence of exceptions. The system can include  
an audit processor for auditing the transactions that occur between the server program and the  
40       client, and a security processor for processing the information to identify a security  
characteristic which is represented of a level of security for selected transaction. The security

5 processor can also provide for security auditing, such that the data being transmitted on the network can be monitored for performing a security audit.

10 The system can further comprise a control module for providing a list of a plurality of server programs and for generating a plurality of the filter modules, each one of which can be associated with a respective one of the plurality of server programs. The system can also include a console module for providing control over operation of the monitor. The console module can couple to a plurality of the agent modules, wherein each of the agent modules can couple to the data memories associated with a particular node. In this way, the console modules can receive data about the operations of any node on the network. Optionally, the  
15 console module can connect to a database memory device for storing the data being collected. The data can be made available to an operator for modifying or repairing the distributed computing system.

20 In a further embodiment, the invention features a system for monitoring operation of a server program executing on a server connected to a network. The system includes a plurality of clients, each capable of requesting service of the server program and having a communication stack for exchanging data with the network. Each client can operate as a background process having a monitor program that includes an interface for coupling into the communication stack and for monitoring the data being passed between the client and the  
25 network, and a filter module that processes the data to detect portions of that data that is representative of communications associated with the server program. A data memory storing the detected portions of data can be included in the system.

30 In a further embodiment, the system monitors loop back operations. Loop back occurs when the server and a distributed application are located on the same client. Loop back information passes between the server and the application via the communication stack without ever going out onto the network. Because the monitor is coupled into the communications stack associated with the client, it can monitor the loop back data that only passes through the communications stack.

35 In another aspect, the invention features methods for monitoring a server program operating on a network. These methods can comprise the steps of: providing a client having a communication stack for passing data between the network and the client; monitoring the data being passed between the client and the network via a monitor having an interface for  
40 coupling into the communication stack; filtering the monitored data to detect portions of the data which are representative of communications associated with the server program; and storing the detected portions of data in a data memory. Methods according to this invention

5 can comprise of further steps of coupling to the data memory via an agent, and processing the detected portions of data to generate information representative of an operation of the server program. Additionally, these methods can comprise the step of processing the information to determine a characteristic of the server program operation.

10

### **BRIEF DESCRIPTION OF THE DRAWINGS**

The objects, features and advantages of the present invention will become more apparent from the following detailed description of exemplary embodiments thereof, taken in  
15 conjunction with the accompanying drawings, in which:

Figure 1 depicts one system according to the invention for providing automated monitoring and management of distributed applications;

Figure 2 is a functional block diagram of a monitoring agent suitable for practice with a system depicted in Figure 1; and

20 Figure 3 depicts one example of a module for collecting details of a distributed process.

Figure 4 is a detailed illustration of the operational details of a module.

Figure 5 depicts another example of a Module for collecting details of a distributed process.

25

### **DETAILED DESCRIPTION**

Figure 1 illustrates a system 10 according to the invention for monitoring and managing a distributed application that includes multiple workstations, and servers. It will be  
30 understood that the system 10 can further include network devices such as printers and network memory devices, which are not shown in the drawing. In particular, Figure 1 depicts workstations 12, 14, 16, and 18, server 20, server 22, Mission Universal Monitor (MUM) agents 30-40, MUM console module 42, MUM database 44, and monitoring station 24.

35 In the system 10, illustrated in Figure 1, each of the workstations 12-18 is representative of a computer system coupled to a network suitable for carrying computer readable information. Each of the network nodes can communicate with either of the servers, 20 or 22 and request services therefrom. Accordingly, the system depicted in Figure 1 has a distributed computing architecture that represents physical and logical distribution of  
40 computing functions across the different workstations, devices and servers.



5           Figure 1 provides a general overview of the structure and operation of systems according to the invention that monitor this distributed processing environment. The system 10 includes the MUM agents 30-40 and the MUM console 42 with the interconnected MUM database 44. Each of the MUM agents 30-40 is associated with the respective one of the workstations or server elements. Moreover, a monitoring agent is associated with each  
10       component of the network to provide for enterprise wide monitoring, as all the processes, including those that are distributed, on the clients and the servers can be monitored. Each MUM agent can physically reside on its associated workstations or server to monitor, *inter alia*, the data that is being exchanged between a program operating on the workstation and a selected one or more of the servers 20 or 22.

15           Consequently, the processing of every device on the network can be monitored, and each of the depicted agents 30-40 can couple to the MUM console module 42 to pass information representative of the collected data to the MUM console 42. The MUM console 42 can store this information within the central database 44 for analysis by an  
20       operator (e.g., a system technician or system administrator). Alternatively, the agents can provide information directly to the MUM database. An application program running on the console 42, or any other system, can view the collected data to show at the component level and at the enterprise level, system performance of any process or component of the enterprise. Moreover, the system administrator can develop enterprise level usage statistics and response  
25       times, develop charts and reports and perform any other relevant data analysis for determining user-defined statistics relevant to the operation of the enterprise.

          Accordingly, it is the function of the MUM agents 30-40 to collect data. To this end, each of the depicted MUM agents 30-40 can be an intelligent monitoring agent that is located  
30       on the managed nodes in the enterprise, wherein any node having an agent is deemed to be a managed node. In the system 10 depicted in Figure 1, each of the nodes on the enterprise has a respective MUM agent, however, it should be apparent to one of ordinary skill in the art of computer engineering, that the number of MUM agents deployed across the enterprise is variable and can be selected according to the character of the application. The MUM agents  
35       can be software modules, such as C++ generated computer programs, that execute on the depicted workstations and servers to configure the servers, workstations and network into systems according to the invention. However, it will be apparent to those of ordinary skill in the art that the MUM agents can be hardware devices, such as electronic circuit card assemblies coupled into the backplane of the individual managed nodes, that monitor  
40       operations of the local system, or can be a combination of hardware and software devices. Any of these embodiments can be practiced with the present invention without departing from the scope thereof.

5

Each of the MUM agents 30-40 can operate autonomously to monitor multiple components including local processor performance, local processor resources, local processor configuration, the operation of the distributed application, the operation of the network, the operation of the various network devices including disks, file systems devices and tape, and other such information. Accordingly, it is a realization of the invention that diagnostic analysis can employ more than a measure of server CPU performance. Each of the monitoring agents 30-40 can be a single, multi-threaded process that can contain information to avoid constant polling by the enterprise monitor console 42. Each of the agents can continuously monitor in real time business transactions, databases, systems and networks detecting and correlating events, initiating corrective actions, and providing event notifications. The MUM agents are capable of understanding business transactions and can collect details of events, resource usage and response times and can pass this information to the MUM console 42 and store it in the MUM database 44.

20

Each of the agents 30-40 can also monitor loop back operations. As shown, loop back 23, 25 occurs when a server and a distributed application are located on the same client. Loop back information passes between the server and the application via the communication stack without ever going out onto the network. Because each agent 38, 40 is coupled into the client communications stack, it can monitor the loop back data that passes only through the communications stack.

25

Figure 2 depicts in functional block diagram form the architecture of one MUM agent 50 suitable for use with the system 10 depicted in Figure 1. The agent 50 can be a software module that executes as a background process on the managed node. In particular, the agent 50 can be an agent residing on a network node that is capable of acting as a SYBASE<sup>TM</sup> client. The agent 50 includes an external event interface 52, a communications interface 54, a tools interface 58, and MUM console interface 60, and event correlation processor 64, a system monitor 70, a network monitor 72, a SYBASE<sup>TM</sup> client monitor 74, and a SYBASE<sup>TM</sup> server monitor 76.

35

The overall architecture of the agent 50 shows that the agent includes a set of monitor elements 70-76 and an external events interface 52 that provide event information about various components of the enterprise to the correlation processor 64. The correlation processor 64 correlates the events to generate data that can be passed to the MUM console 42, or passed to other tools, including other management tools or instrumentation code for setting off alarms, activating a beeper, sending a fax via modem, sending e-mail to system administrators or taking corrective action. Accordingly, the agent 50 collects details of

40

5 events and processes these details in the correlation processor 64 to generate information representative, among other things, of business transactions.

To this end the external events interface 52 and the monitor elements 70-76 can collect details about events. The external events interface 52 can be comprised of a set of  
10 program modules operating on the local system for detecting certain events. These external events can be Simple Network Management Protocol (SNMP) traps from other devices, events from user and system processes.

The monitor elements 70-76 can include code modules that operate on the node for  
15 collecting information about certain events and can also include a programming interface for receiving calls from those code modules to pass the notification of the detected event on to the monitor elements. The monitor elements 70-76 can receive event notifications from code that is monitoring any of the enterprise components relevant to the local system, which for the agent 50, can include system events, network events, and SYBASE client/server events. The  
20 programming interface of the monitor elements 70-76 can be an exported C++ based API that receives calls from this code upon detection of certain events. For example, the node can be running code for trapping the general protection fault, which can be defined as a system event. The code will make an API call to the agent 50 to notify the system monitor element 70 of the detected failure, and the system monitor element 70 can pass notification to the  
25 correlation processor 64. The API can encapsulate the code's service protocol to remove the operating characteristics of the code from the operation of the other agent components. This allows the detection code to act as plug-in modules that the user can select for configuring which events are to be monitored. Moreover, the user can define events of interest, for monitoring by the agent. Any code suitable for passing event details to any of the monitor  
30 elements within the agent 50 can be practiced with the present invention, without departing from the scope thereof.

In particular, the system monitor 70 can collect information about the operation of the local system. To this end, the system monitor 70 can include code modules for collecting  
35 information regarding processor load, memory usage, available memory space, and other similar information that is descriptive of the operation of the local workstation or server. The development of such code is well known in the art, and any suitable code can be practiced with the invention without departing from the scope thereof. Also, each agent can take action on the local system such as setting off alarms, activating a beeper, sending a fax via modem,  
40 sending e-mail to system administrators or taking corrective action.

5 In contrast to the system monitor 70, the monitors 72-76 are to monitor events associated with distributed processes. Accordingly, the details relevant to the monitored events require information about the distributed processing operations that are occurring. A realization of the present invention is that the monitors 72-76 can passively collect information about the distributed process by monitoring the network communications that  
10 occur during the distributed process. To this end, each monitor element can include an interface to the network communications stack to passively monitor communications between the distributed process elements.

Figure 3 depicts one example of a module 80 for collecting details of a distributed  
15 process, and suitable for use on a SUN SOLARIS™ platform. The module 80 monitors the network communications between database software 51 disposed on the local client and a selected group of servers and pass copies of the communications to the agent 50 for processing and for determining which events, if any, have occurred. In particular, the module 80 can enable monitoring by the agent 50 of the local client's database software 51 (e.g.,  
20 SYBASE, CORBA, ORACLE) or other distributed process applications 53 having traffic that passes through the TCP stack of the managed node.

The module 80 is comprised of an agent 50 and STREAMS modules 55. The agent 50 includes a TAP API 57 and a socket library 59. The STREAMS modules 55, which  
25 include a TAP module 61 and a TCP STREAMS driver 63, can be constructed according to well known principles in the art of computer engineering, including those set forth in text The Unix Operating System, by Richard Bachman. The TAP module 61 autopushes on top of the TCP STREAMS stack 65 so that all TCP traffic in and out of the managed node passes through the module 80. The module 80 is aware of the communications protocol for the  
30 distributed process or processes being monitored, such as ORACLE or SYBASE. In this way, the module 80 can filter from the traffic those portions that are relevant to the agent 50 and pass copies of this traffic to the agent 50.

Figure 4 is a detailed illustration of operational details of the module 80 (as shown in  
35 Figure 3) on the SUN SOLARIS™ platform. The module 80 maintains a list 84 of the servers to be monitored. In one embodiment, the list of servers is provided to the module 80 by the agent 50, which can receive the list from the MUM console 42. All inbound and outbound traffic on connections to the listed servers is passed by module 80 to the agent 50.

40 In operation, for each connected stream, the module 80 creates a context data structure for storing information. The context is then linked, as shown, to the corresponding STREAMS queues, read and write. The context stores information about the connected

5 stream that describes the type of connection. The module 80 also opens a context data structure 94 for communicating to the agent 50. The module 80 can store data about event details within this context 94, and the agent 50 can read the data out, and pass the information to the correlation processor 64. The tap table 82 stores a list of the connected streams context data structures, the list of all servers being monitored, and the context data structure for  
10 communicating with the agent 50.

Each time a connection is established the module creates a context. The module then determines the server address for the connection by generating a sequence of M\_IOCTL requests that are sent downstream. Response from the TCP stack is captured and prevented  
15 from being sent upstream, and the server IP address is resolved. If the address matches one of the addresses in the list 84, the connection is marked as being monitored, and the module 80 begins monitoring. During monitoring, copies of all traffic sent or received under the context of a monitored connection is passed to the upstream queue of the agent communication context 94, for being passed upstream to the agent 50. In this way the agent 50 receives  
20 copies of all traffic for any connection to any of the selected servers.

The information passed upstream by module 80 to the agent 50 is sent to the event correlation processor 58. The event correlation processor is a software module that can process event detail information to determine certain transaction level information. For  
25 example, the module 80 can pass a SYBASE logon request to the agent 50. The event correlation processor can receive the logon request and monitor the connection until a logon acknowledge is sent by the SYBASE server. By comparing the time difference between these two events, the event correlation processor 58 can determine a measure of the response time of the distributed process. Other similar metrics that can also be generated to provide end-to-  
30 end level analysis of system performance.

Figure 5 depicts another example of a module 180 for collecting details of a distributed process, and suitable for use on a WINDOWS NT™ platform. The module 180 employs a different architecture than the module 80, but performs the same functions. That  
35 is, the module 180 can enable monitoring by the agent 150 of the local client's database software 151 or other distributed process applications 153, 155 having traffic that passes via system services 176 through the TCP stack of the managed node.

The module 180 includes an agent 150 and a TAP driver 163. The agent 150 includes  
40 a TAP API 157, and the TAP driver 163 includes a Tap device 161 and a TapFilter device 162. The Tap device 161 communicates with the TAP API 157 to set up monitoring parameters and to supply monitoring data. The TapFilter device 162 attaches on top of the

5 TCP device 167 of the TCP/IP driver 165 to monitor all TCP traffic in and out of the managed node. The TapFilter device 162 uses a feature of the Windows NT™ driver layering architecture to attach itself to the TCP device 167. In particular, the TapFilter device 162 uses an operating system call (i.e., IoAttachDevice) to insert itself into the data stream for the TCP device. Thus, any data to or from the TCP device passes transparently through the  
10 TapFilter device 162.

The TCP/IP driver 165 also includes a UDP device 169 and an IP device 171 that support other sub-protocols in the TCP/IP family of protocols. Although not shown, the TapFilter device 162 could attach on top of the UDP device 169 and/or the IP device 171 to  
15 monitor all data traffic for such devices.

It will be understood that the depicted modules 80 and 180 are only illustrative embodiments of a module for interfacing to the network communication stack. Other modules can be practiced with the invention. For example, referring again to Figure 1, it can  
20 be seen that different types of workstations are depicted in system 10 to show that system 10 is a distributed system having heterogeneous operating environments. The workstations can be of different architectures, both hardware and software, and the servers 20 and 22 can similarly be of different hardware or software architecture. For example, the workstation 12 can be a SUN workstation having a module as depicted in Figure 2. Moreover, the network  
25 system that interconnects the workstations and the servers can be a local area network, a wide area network, a metropolitan area network, or a combination of either. The point is that in a distributed computing architecture the processing that occurs to implement a particular service, whether it is e-mail, a database, a word processing program, or any other service or computer applications, it is distributed across multiple processors that are somehow  
30 interconnected for exchanging data.

It will thus be seen that the invention efficiently achieves the objects set forth above. Moreover, it will be understood that various substitutions, additions and modifications can be made to the invention without departing therefrom and that embodiments depicted and  
35 described are merely illustrative of the invention and are not to be read in a limiting sense; with the scope of the invention defined by the following claims to the fullest extent allowed by the terms therein.

5

Claims

1. A system for monitoring a server program operating on a network, comprising  
a client having a communications stack for passing data between said network  
and said client,  
10 a monitor having  
an interface for coupling into said communications stack and for  
monitoring said data being passed between said client and said network, and  
a filter module for processing said data to detect portions of said data  
15 representative of communications associated with said server program, and  
a data memory for storing said detected portions of data.
2. A system according to claim 1, further comprising  
an agent for coupling to said data memory and for processing said detected  
20 portions of data to generate information representative of an operation of said server program.
3. A system according to claim 2, further comprising  
a user module for receiving said information from said agent, and for  
processing said information to determine a characteristic of said server program operation.  
25
4. A system according to claim 3, wherein said user module includes  
a usage detector for processing said information to determine a characteristic  
representative of a volume of use of said server program by said client.  
30
5. A system according to claim 3, wherein said user module includes  
an error detector for processing said information to determine a characteristic  
representative of a transmission error occurring in a transmission between said server  
program and said client.  
35
6. A system according to claim 3, wherein said user module includes  
a response detector for processing said information to determine a  
characteristic representative of a response time for a service provided by said server program.

- 5     7.     A system according to claim 3 wherein said user module includes  
         an audit processor for auditing transactions between said server program and  
         said client.
- 10     8.     A system according to claim 3 wherein said user module includes  
         a security processor for processing said information to identify a security  
         characteristic representative of a level of security
- 15     9.     A system according to claim 1, further comprising  
         a control module for providing a list of a plurality of server programs and for  
         generating a plurality of said filter modules, each associated with a respective one of said  
         plurality of server programs.
- 20     10.    A system according to claim 1, further comprising  
         a console module, for providing control over operation of said monitor.
- 25     12.    A system for monitoring operation of a server program executing on a server  
         connected to a network, comprising  
         a plurality of clients, each capable of requesting service of said server program, and  
         each having a communications stack for exchanging data with said network, and  
         wherein each of said plurality of clients operates a background process having,  
         a monitor program including,  
         an interface for coupling into said communications stack and for  
         monitoring said data being passed between said client and said network, and  
30           a filter module for processing said data to detect portions of said data  
         representative of communications associated with said server program, and  
         a data memory for storing said detected portions of data.
- 35     13.    A system according to claim 12, wherein  
         the interface for coupling into said communications stack monitors loop back  
         data that passes through said communications stack without going out onto the network.



- 5 14. A method for monitoring a server program operating on a network, comprising the steps of
- providing a client having a communications stack for passing data between said network and said client,
- monitoring said data being passed between said client and said network via a
- 10 monitor having an interface for coupling into said communications stack,
- filtering said monitored data to detect portions of data representative of communications associated with said server program, and
- storing said detected portions of data in a data memory.
- 15 15. A method according to claim 14, comprising the further step of coupling to said data memory via an agent, and
- processing in said agent said detected portions of data to generate information representative of an operation of said server program.
- 20 16. A method according to claim 15, comprising the further step of processing said information to determine a characteristic of said server program operation.

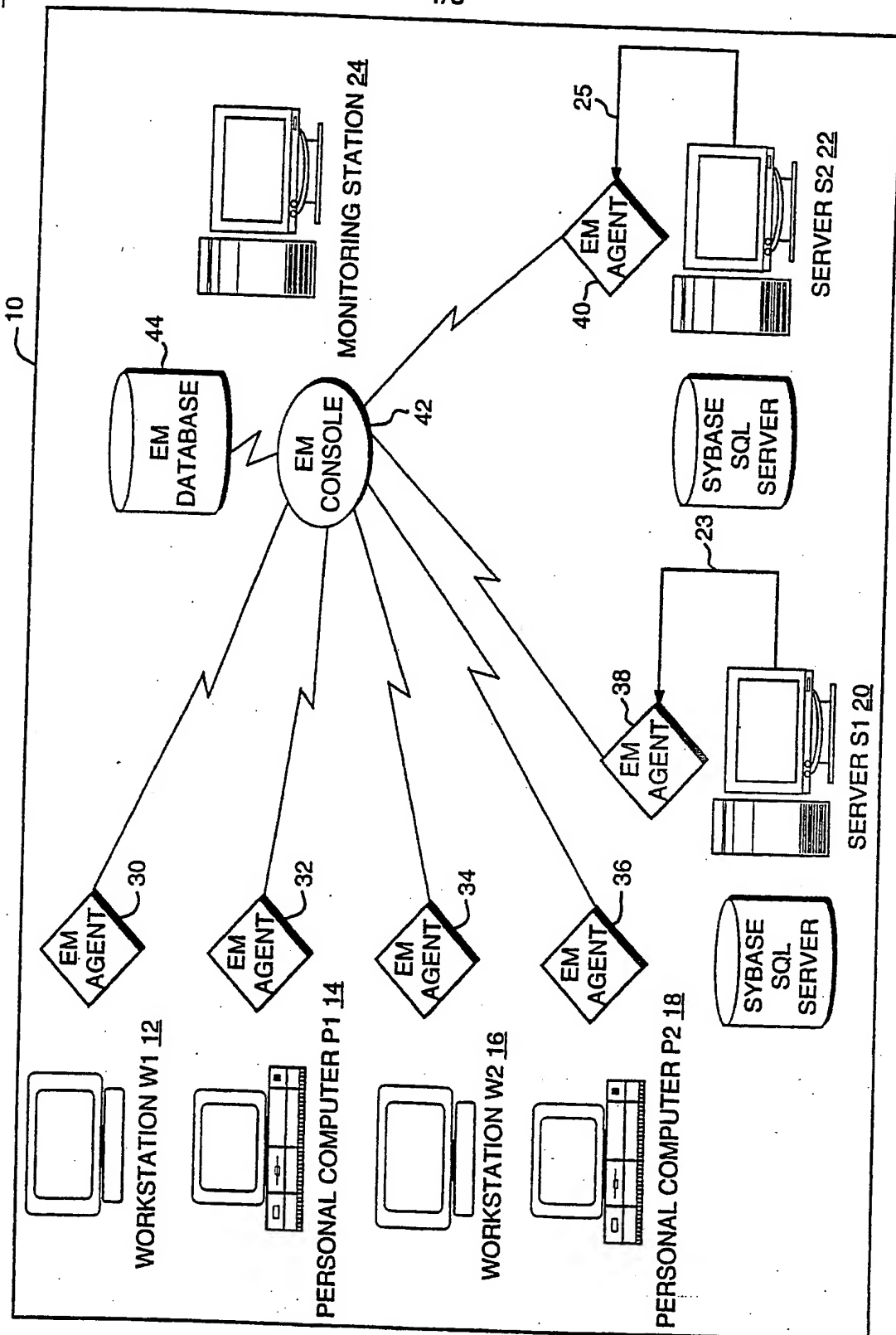


FIG. 1

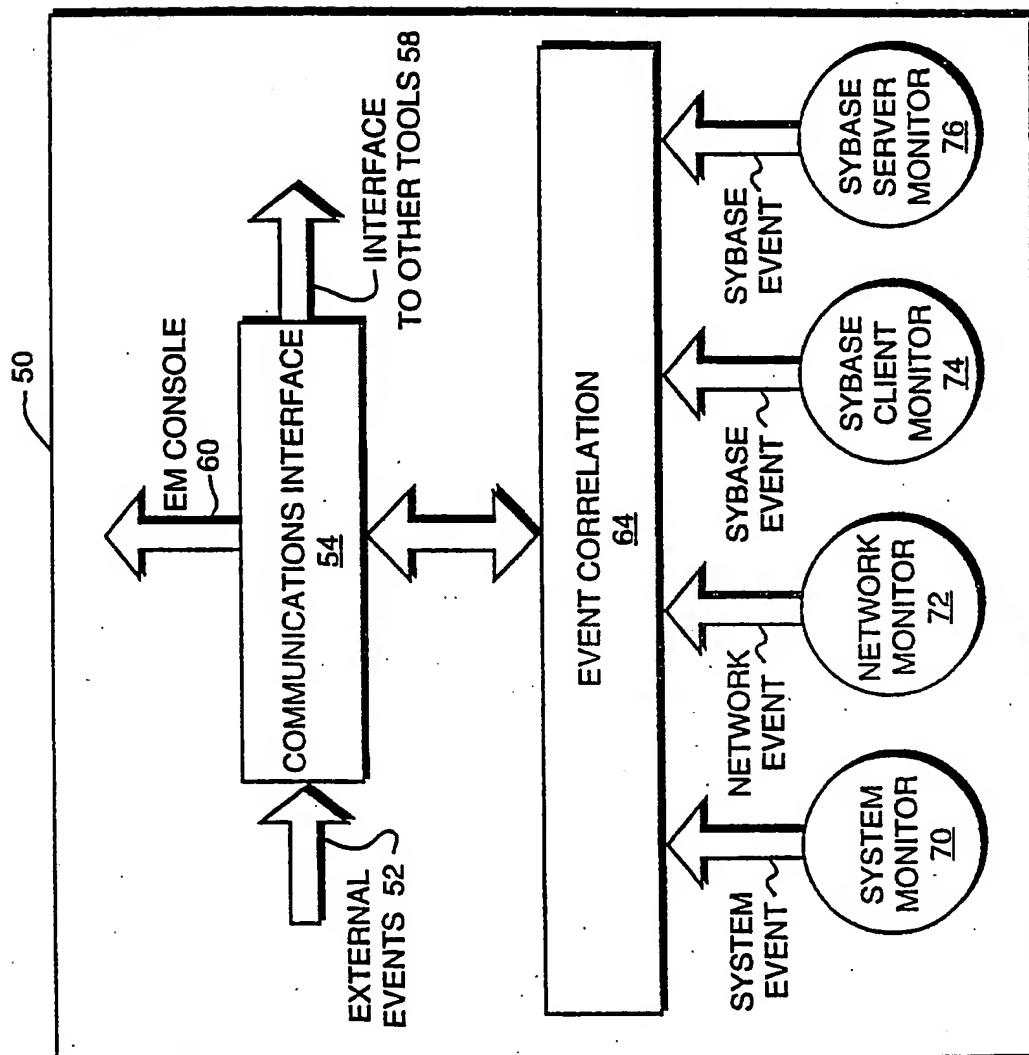


FIG. 2

3/5

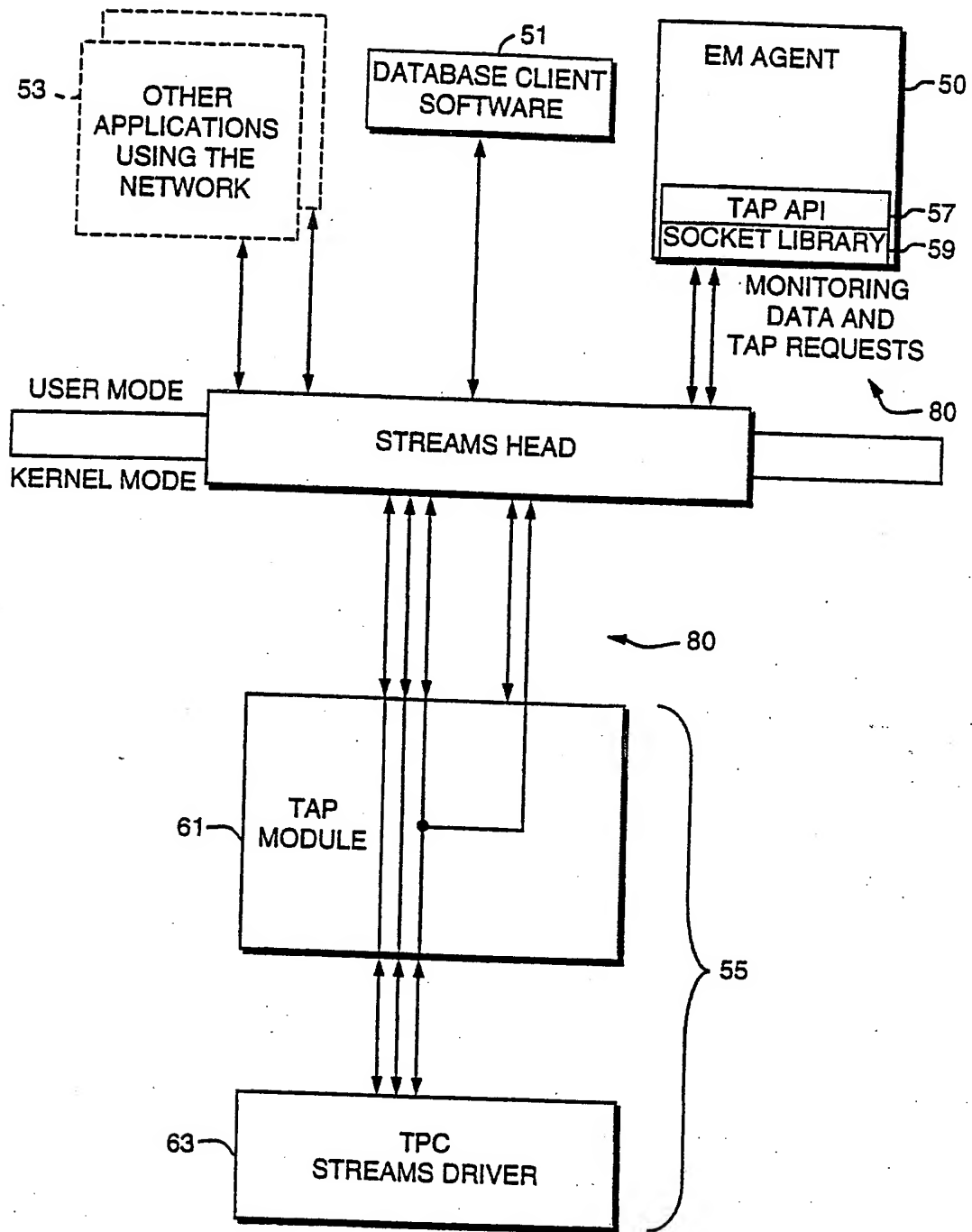


FIG. 3

4/5

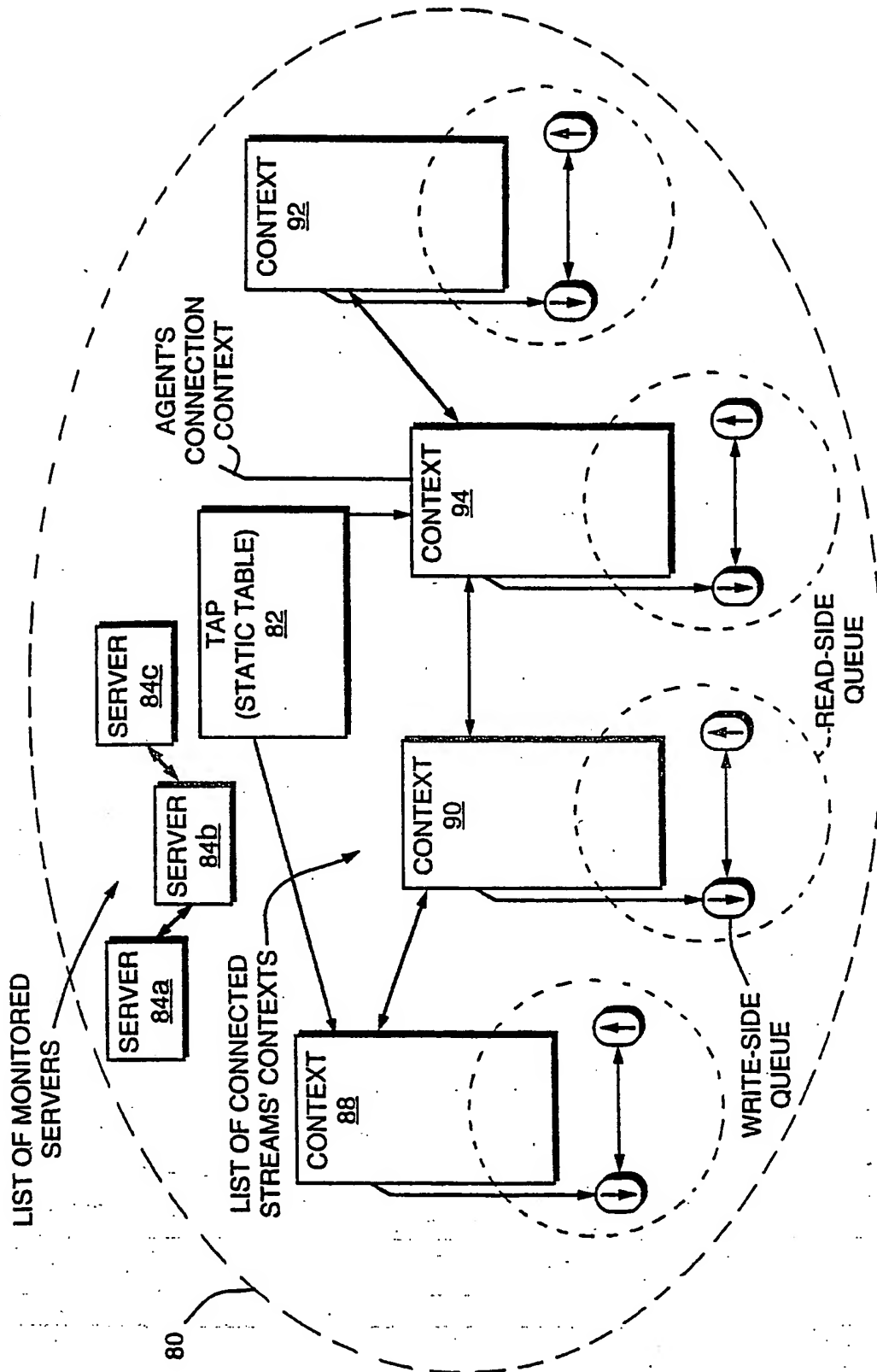


FIG. 4

5/5

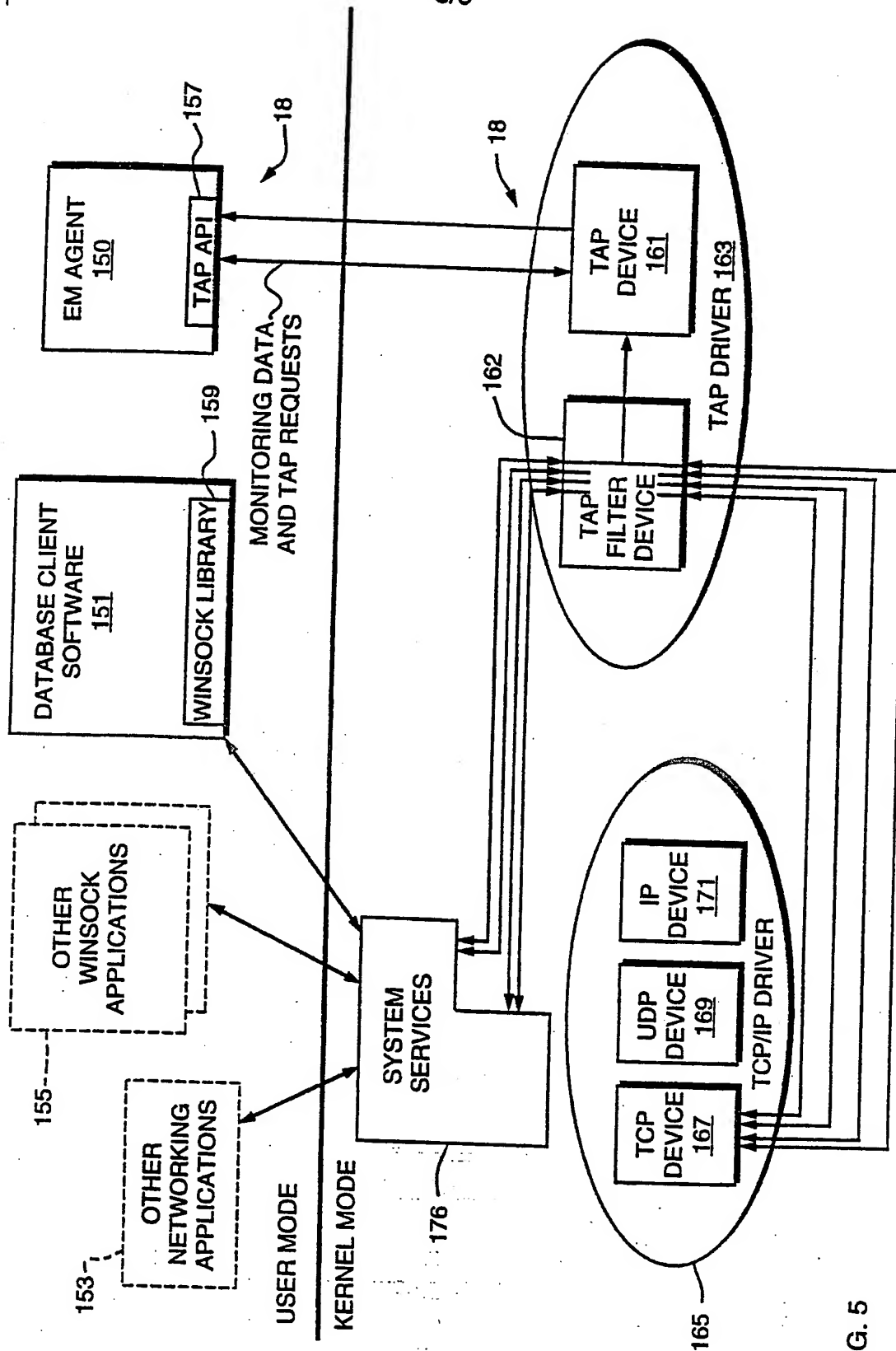


FIG. 5

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 H04L12/26 H04L29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 462 691 A (IBM) 27 December 1991 see abstract see page 1, line 1 - page 7, line 13 see figures 1-4 ---	1, 11, 13
A	US 5 101 402 A (CHIU DAH-MING ET AL) 31 March 1992 see abstract see column 1, line 1 - column 7, line 62 see figure 16 --- -/--	1, 11, 13

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention.
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

10 August 1998

Date of mailing of the international search report

18/08/1998

Name and mailing address of the ISA  
European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3018

Authorized officer

Lievens, K

# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/US 98/05162

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>HUNT R: "SNMP, SNMPV2 AND CMIP - THE TECHNOLOGIES FOR MULTIVENDOR NETWORK MANAGEMENT"</p> <p>COMPUTER COMMUNICATIONS,</p> <p>vol. 20, no. 2, March 1997, pages 73-88,</p> <p>XP000688489</p> <p>see abstract</p> <p>see page 73, left-hand column, paragraph 1</p> <p>- page 81, left-hand column, paragraph 4</p> <p>-----</p>	1,11,13



Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0462691 A	27-12-1991	CA 2019327 A	19-12-1991
		JP 1993559 C	22-11-1995
		JP 5067011 A	19-03-1993
		JP 7027502 B	29-03-1995
US 5101402 A	31-03-1992	NONE	

**THIS PAGE BLANK (USPTO)**

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**

**THIS PAGE BLANK (USPTO)**